Massachusetts Department of ENVIRONMENTAL PROTECTION

t e c h n i c a l u p d a t e

Characterization of Risks Due to Inhalation of Particulates by Construction Workers

Update to: Section 7.3 and Appendix B of the MA DEP *Guidance for Disposal Site Risk Characterization – In Support of the Massachusetts Contingency Plan* (1995)

Introduction

In the past, the Massachusetts Department of Environmental Protection (DEP) has not required quantification of risks due to inhalation of respirable particulates (fugitive dust) by heavy construction/utility workers at 21E sites. Recently, DEP quantitatively compared risks associated with enhanced incidental ingestion of soil and those associated with inhalation of respirable particulates, assuming an equal concentration of OHM in both media. The results of this analysis clearly demonstrated that, for a number of chemicals in the utility/heavy construction worker scenario, risks associated with inhalation of respirable particulates contribute to a significant portion of total risk.

Conclusion and Recommendation

DEP concludes that, for a heavy construction/utility worker, risks associated with inhalation of airborne particles at 21E sites should be explicitly evaluated. In order to quantify these risks, DEP recommends using the methods described in the following sections.

Discussion

Dose-Response and Exposure Assessments

In accordance with DEP's 1995 Guidance for Disposal Site Risk Characterization (Guidance), characterization of risk for an OHM is preceded by a dose-response assessment and an exposure assessment. Methods to obtain chemical-specific dose-response values and relative absorption factors (RAFs) are presented in Section 7.2 of the Guidance.

Methods to estimate exposure are presented in Section 7.3. However, the Guidance does not fully describe a method to account for the two uptake pathways following inhalation of airborne particulates by a worker: 1) That by the gastrointestinal (GI) tract following coughing up and subsequent swallowing of particulates trapped by the mucosa of the upper respiratory track and 2) That by the respiratory system following inhalation into the lungs. To calculate the exposure associated with these two uptake pathways, DEP assumes the following for the construction worker scenario:

- 100% of respirable particulate mass is equal to or less than 30 microns in diameter (≤PM-30) (DEP, 1997)
- 40% of total respiratory particulate mass is equal to or less than 10 microns in diameter (≤PM-10) (Guidance)
- 100% of inhaled particulates greater than 10 microns but less than or equal to 30 microns are swallowed. 50% of inhaled particulates equal to or less than 10 microns are swallowed (DEP, 1997)
- 50% of inhaled particulates equal to or less than 10 microns enters the lungs (DEP, 1997)

Based on these assumptions, the effective exposure concentration of respirable particulates for the GI system is 2 times the concentration of PM-10, while that for the lungs is 0.5 times the concentration of PM-10. Using these effective exposure concentrations, OHM average daily doses for the GI and respiratory systems can be estimated using modified versions of equations 7-18 in the Guidance as follows:

Average Daily Dose for the GI System ($ADD_{inhalation-GI}$)

$$ADD_{inhalation-GI} = \frac{[OHM_{particulate}] \times 2 \times [PM_{10}] \times Inh \times RAF \times EF \times ED \times EP \times C}{BW \times AP}$$

where,

$ADD_{inhalation-GI}$ =	Average daily dose due to coughing up and subsequent ingestion of inhaled particulates; expressed in mg/kg-day
$[OHM_{particulate}]$ =	Concentration of oil/hazardous material in airborne particulates
$[PM_{10}]$ =	Concentration in air of particulates less than or equal to 10 microns in diameter
Inh =	Inhalation rate for the receptor of concern during the period of exposure
RAF =	Relative Absorption Factor
EF =	Number of exposure events during the exposure period divided by the number of days in the exposure period
ED =	Duration of each exposure event
EP =	Duration of the exposure period
BW =	Body weight of the receptor of concern during the averaging period
AP =	Averaging period
C =	Appropriate unit conversion factor

Average Daily Dose for the Respiratory System ($ADD_{inhalation}$)

$$ADD_{inhalation} = \frac{[OHM_{particulate}] \times 0.5 \times [PM_{10}] \times Inh \times RAF \times EF \times ED \times EP \times C}{BW \times AP}$$

where,

$ADD_{inhalation}$ =	Average daily dose due to inhaled particulates entering the lungs; expressed in mg/kg-day
$[OHM_{particulate}]$ =	Concentration of oil/hazardous material in airborne particulates
$[PM_{10}]$ =	Concentration in air of particulates less than 10 microns in diameter
Inh =	Inhalation rate for the receptor of concern during the period of exposure
RAF =	Relative Absorption Factor
EF =	Number of exposure events during the exposure period divided by the number of days in the exposure period
ED =	Duration of each exposure event
EP =	Duration of the exposure period
BW =	Body weight of the receptor of concern during the averaging period
AP =	Averaging period
C =	Appropriate unit conversion factor

Massachusetts Department of
Environmental Protection
One Winter Street
Boston, MA 02108-4746

Commonwealth of
Massachusetts
Jane Swift, Governor

Executive Office of
Environmental Affairs
Bob Durand, Secretary

Department of
Environmental Protection
Lauren A. Liss, Commissioner

Produced by the
Office of Research & Standards,
April 2002.
Printed on recycled paper.

This information is available in
alternate format by calling our
ADA Coordinator at
(617) 574-6872.

DEP dose-response values for inhalation exposure (i.e., unit risk factor and reference concentration) are expressed on a mass-OHM per volume-air basis, using the assumption that a person weighs 70 kg and has a daily inhalation rate (Inh_{day}) of 20 m^3. Therefore, prior to the characterization of risk, $ADD_{inhalation}$ (mg/kg-day) for the OHM must be converted to an average daily exposure ($ADE_{inhalation}$) (mg/m^3) in order to make it compatible with the corresponding dose-response values. This can be accomplished by equation 7-21 in the Guidance:

$$ADE_{inhalation} = \frac{ADD_{inhalation} \times BW}{Inh_{day}}$$

where,

$ADE_{inhalation}$ =	Average daily oil/hazardous material concentration to which a receptor is exposed; expressed in mg/m^3
$ADD_{inhalation}$ =	Average daily dose due to inhaled particulates entering the lungs
BW =	Body weight of the receptor of concern during the averaging period
Inh_{day} =	Daily inhalation rate of the receptor of concern

DEP Recommended Default Values

For the equations above, DEP recommends the following default measurement units and values:

$[OHM_{particulate}]$ =	site-specific; expressed as mg/kg
$[PM_{10}]$ =	60 $\mu g/m^3$ (Appendix B, Guidance)
Inh =	60 l/min (Appendix B, Guidance)
RAF =	chemical-specific; dimensionless
EF =	1 event/day (Appendix B, Guidance)
ED =	8 hours/event (Appendix B, Guidance)
EP =	130 days (Appendix B, Guidance)
BW =	58 kg (50^{th} percentile of female body weights, ages 18-24, Table 7-5, Appendix B, U.S. EPA ,1997)
AP =	182 days for noncancer risk; 25,550 days for cancer risk (Appendix B, Guidance)
Inh_{day} =	20 m^3/day
C =	6×10^{-11} (60 min/hour; 1×10^{-9} mg/µg; 0.001 m^3/l)

The default value of 60 $\mu g/m^3$ for $[PM_{10}]$ presented in the Guidance was based on data collected from non-construction sites. In light of a 1998 report on PM_{10} concentrations near construction sites for the Central Artery Tunnel Project (Massachusetts Highway Department), DEP re-evaluated the appropriateness of the 60 $\mu g/m^3$ default value. The Highway Department report presents data on PM_{10} concentrations obtained June through October, 1997, at 12 locations along the Central Artery. Samples were obtained between 30 and 300 feet outside construction fence lines. One sampling location (Site 11) was situated near the Subaru Pier stockpile facility. During the sampling period, over 1,200 dump trucks per day visited the facility to deposit excavated material. Therefore, DEP did not consider results from this location because such a high truck volume is not representative of most construction sites.

Massachusetts Department of
Environmental Protection
One Winter Street
Boston, MA 02108-4746

Commonwealth of
Massachusetts
Jane Swift, Governor

Executive Office of
Environmental Affairs
Bob Durand, Secretary

Department of
Environmental Protection
Lauren A. Liss, Commissioner

Produced by the
Office of Research & Standards,
April 2002.
Printed on recycled paper.

This information is available in
alternate format by calling our
ADA Coordinator at
(617) 574-6872.

The arithmetic means of PM_{10} concentrations for the remaining 11 locations ranged from 30 to 77 µg/m^3, while the arithmetic mean of these values (i.e., the mean of the means) was 53 µg/m^3. While these values (range of means and mean of means) are not direct measurements of fugitive dust at construction sites, they do suggest that a PM_{10} concentration of 60 µg/m^3 for such sites is reasonable. Use of the Central Artery data is conservative in that automobile emissions from nearby roadways likely contributed to PM_{10} measurements. However, this conservativeness is counterbalanced by the fact that PM_{10} concentrations are likely to be higher at the construction site relative to where the measurements were taken (i.e., 30 – 300 feet distant) and that the DEP method described above does not account for the possibility that particulates larger than 30 microns in diameter are present at construction sites.

Risk Characterization

The $ADD_{inhalation\text{-}GI}$ and the $ADE_{inhalation}$ calculated above can be used to characterize risks to a construction worker inhaling airborne particulates containing the OHM. Noncancer risks due to GI and respiratory system uptake of inhaled particulates can be calculated using a modification of equations 7-27 and 7-28, respectively, from the Guidance. Therefore, the noncancer risk for the OHM is calculated as follows:

$$HI = \left(\frac{ADD_{inhalation-GI}}{RfD} \right) + \left(\frac{ADE_{inhalation}}{RfC} \right)$$

where,

HI = The Hazard Index associated with exposure to the chemical following inhalation of chemical-containing airborne particulates; dimensionless

$ADD_{inhalation\text{-}GI}$ = Average daily dose due to coughing up and subsequent ingestion of inhaled particulates; expressed in mg/kg-day

RfD = The oral reference dose or appropriate substitute toxicity value identified for the chemical; expressed in mg/kg-day

$ADE_{inhalation}$ = Average daily concentration to which a receptor is exposed; expressed in mg/m^3

RfC = The reference concentration or substitute toxicity value identified for the chemical; expressed in mg/m^3

Excess lifetime cancer risks due to GI and respiratory system uptake of inhaled particulates can be calculated using a modification of equations 7-31 and 7-32, respectively, from the Guidance. Therefore, cancer risks associated with the OHM are calculated as follows:

$$ELCR = \left(ADD_{inhalation} - GI \times CSF \right) + \left(ADE_{inhalation} \times URF \right)$$

where,

ELCR = The excess lifetime cancer risk associated with exposure to the chemical following inhalation of chemical-containing airborne particulates; dimensionless

Massachusetts Department of Environmental Protection
One Winter Street
Boston, MA 02108-4746

Commonwealth of Massachusetts
Jane Swift, Governor

Executive Office of Environmental Affairs
Bob Durand, Secretary

Department of Environmental Protection
Lauren A. Liss, Commissioner

Produced by the Office of Research & Standards, April 2002.
Printed on recycled paper.

This information is available in alternate format by calling our ADA Coordinator at (617) 574-6872.

$ADD_{inhalation\text{-}GI}$ = Average daily dose due to coughing up and subsequent ingestion of inhaled particulates; expressed in mg/kg-day

CSF = The cancer slope factor identified for the chemical; expressed in mg/kg-day

$ADE_{inhalation}$ = Average daily concentration to which a receptor is exposed; expressed in mg/m^3

URF = The unit risk factor identified for the chemical; expressed in mg/m^3

For Further Information

For further information about this Technical Update, please contact Andrew Friedmann, Massachusetts Department of Environmental Protection, One Winter Street, Boston, MA 02108, telephone: (617) 292-5841, email: Andrew.Friedmann@state.ma.us.

References

DEP. 1995. Guidance for disposal site risk characterization. Massachusetts Department of Environmental Protection, Bureau of Waste Site Cleanup and Office of Research and Standards. Interim Final Policy. BWSC/ORS-95-141.

DEP. 1997. Methodology for relating soil contaminant levels and risk to human health. Massachusetts Department of Environmental Protection, Office of Research and Standards. Section 6.1.4.

Massachusetts Highway Department. 1998. Central Artery (I-93)/Tunnel (I-90) Project: Particulate Matter (PM_{10}) Monitoring and Field Inspection Program for Mainline Construction (June through October, 1997). July, 1998.

U.S. EPA. 1997. Exposure Factors Handbook. Volume 1. Office of Research and Development. EPA/600/P-95/002Fa. August 1997.

Massachusetts Department of
Environmental Protection
One Winter Street
Boston, MA 02108-4746

Commonwealth of
Massachusetts
Jane Swift, Governor

Executive Office of
Environmental Affairs
Bob Durand, Secretary

Department of
Environmental Protection
Lauren A. Liss, Commissioner

Produced by the
Office of Research & Standards,
April 2002.
Printed on recycled paper.

This information is available in
alternate format by calling our
ADA Coordinator at
(617) 574-6872.